High Magnetic Fields

The National High Magnetic Field Laboratory at Los Alamos develops for use in basic research the world's most powerful pulsed electromagnets, more than a million times stronger than the Earth's magnetic field. It is one of three national magnetic field campuses working together with the support of the National Science Foundation, State of Florida and the Department of Energy. Researchers worldwide visit the NHMFL to perform experiments on a wide range of materials, including high-temperature superconductors.

Magnetic Research

Research in high magnetic fields allows scientists to study matter at the molecular level. Improved understanding of materials, chemistry, physics and biological structures through research with high magnetic fields has led to a range of enhanced modern technologies, many of which are now taken for granted. Among them are computers, motors, plastics, high-speed trains, high-temperature superconductors and magnetic resonance imaging (MRI).

Pulsed Magnets

Los Alamos' focus is pulsed magnets, while the collaborating campuses at Florida State University and the University of Florida concentrate on continuous fields, magnetic resonance and ultra-low temperatures at high magnetic fields.

The pulsed magnetic field laboratory at Los Alamos provides the collaborating team and other researchers with a unique resource because it enables them to tailor the pulse shape to perform a wide range of measurements.

It's unique for another reason. Powering the world's most powerful long-pulsed magnet is a 1.4-billion-watt generator, itself the largest among magnetic-power sources. It can produce enough energy to power the state of New Mexico.

Two types of pulsed magnets are developed at Los Alamos. One is non-destructive. The second, labeled destructive, produces higher-power energy but has experimental limitations. It also blows itself up in the process of creating a powerful field. Magnets at Los Alamos have a range of pulse times from millisecond duration pulses, which are driven by capacitor banks, to two-second pulses driven by the 1.4-billion-watt generator, which gives researchers the flexibility to tailor the pulse shape.

Inspecting he generator that is the largest among magnetic-power sources.

Measure of Strength

Scientists measure magnetic fields in units of *teslas* and *gauss*, with one tesla equal to 10,000 gauss. The Los Alamos facility routinely provides long-pulsed magnetic fields of 60 teslas (or 600,000 gauss) and expects some day to increase that, perhaps to 100 teslas (one million gauss).

By way of comparison, the Earth's magnetic field is just 1/4 to 1/2 *gauss*, depending on where you are in the world. The 60 tesla/600,000 gauss magnet today can deliver more than one million times the magnetic field found naturally on Earth. It reaches the peak field for just 100 milliseconds, but the entire pulse is two seconds in duration. When charged, this magnet contains the energy of nearly 200 sticks of dynamite.

Design and Construction

High stress and abnormal heating cause problems within powerful magnets. New materials are necessary to build them because ordinary steel would burst under the stresses involved in confining the high magnetic field inside the magnet.

Choosing specific types of wires to create the coil is also difficult. Usually a good conductor of electricity, ordinary copper wire does not have the strength to handle the stress the magnetic field applies to the magnet. The high-tech wires used instead are a combination of copper strengthened by fine filaments of aluminum, silver or niobium.

The typical pulsed magnet's central component, its coil, is formed when the wire is wrapped around a cylinder for 300 turns. A huge surge of electricity pushed through the coil induces a burst of magnetic field, creating stresses of many hundreds of tons in the process.

Research Applications

Studying materials at extreme temperatures has advanced knowledge of solid state physics, but thermal measurements in magnetic fields is challenging. Scientists at the NHMFL have accomplished the first specific heat measurements in magnetic fields up to 60 teslas. They also have probed the electron state of metals with heavy electron compounds, using low temperatures and magnetic field pressure. In other work, radio frequency in high magnetic fields has been used to measure the characteristics of magnetic field and temperature of superconducting compounds.

Quick Facts

Budget: $7.8 million
Technical and Support Staff: 23
Students and Postdocs: 9
Other students: 5

Since 1943, Los Alamos has created and applied advanced science and technology to solve critical challenges in national defense and civilian research.

Exterior view of the 1.4-billion-watt generator.

Los Alamos NATIONAL LABORATORY

Los Alamos National Laboratory is operated by the University of California for the U.S. Department of Energy's National Nuclear Security Administration

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